

Search for Dark Matter with Cryogenic Neon

CLEAN Collaboration

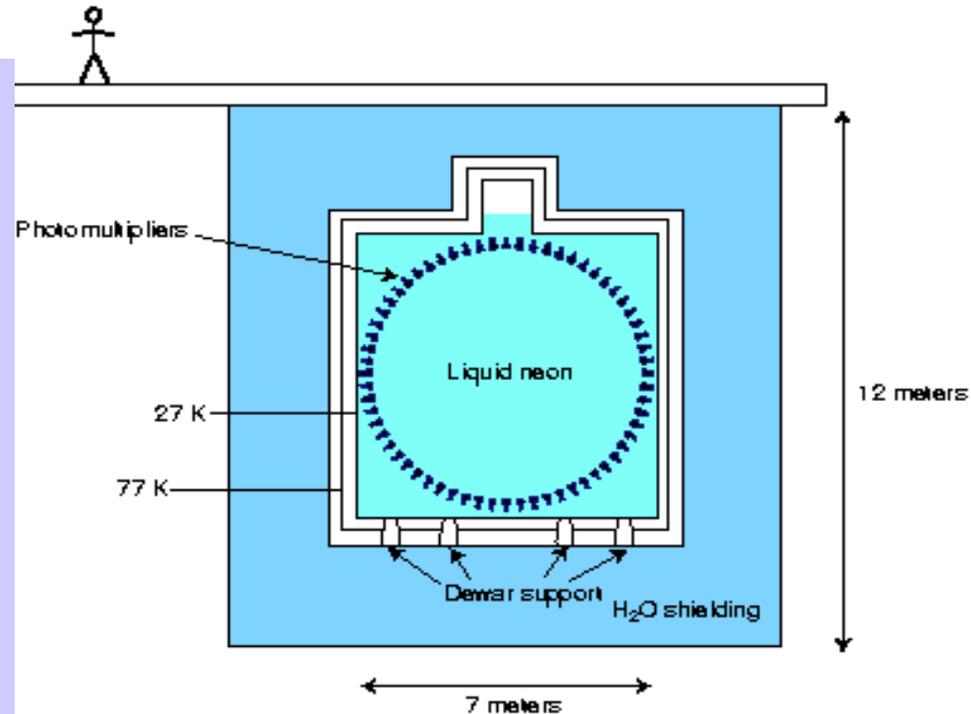
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Nuclear Physics

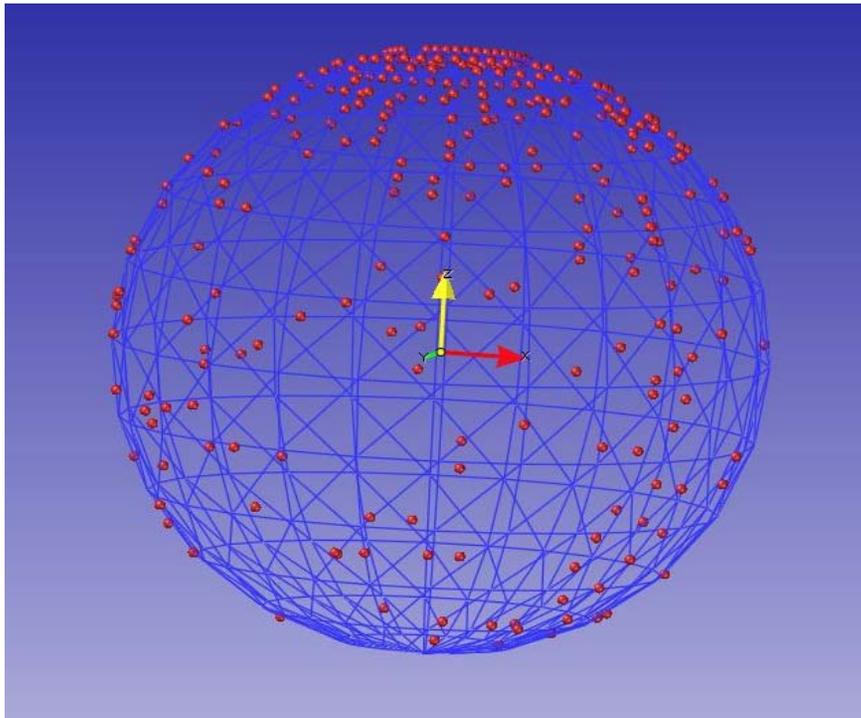
CLEAN for dark matter and pp neutrinos

Why Dark Matter with Neon?

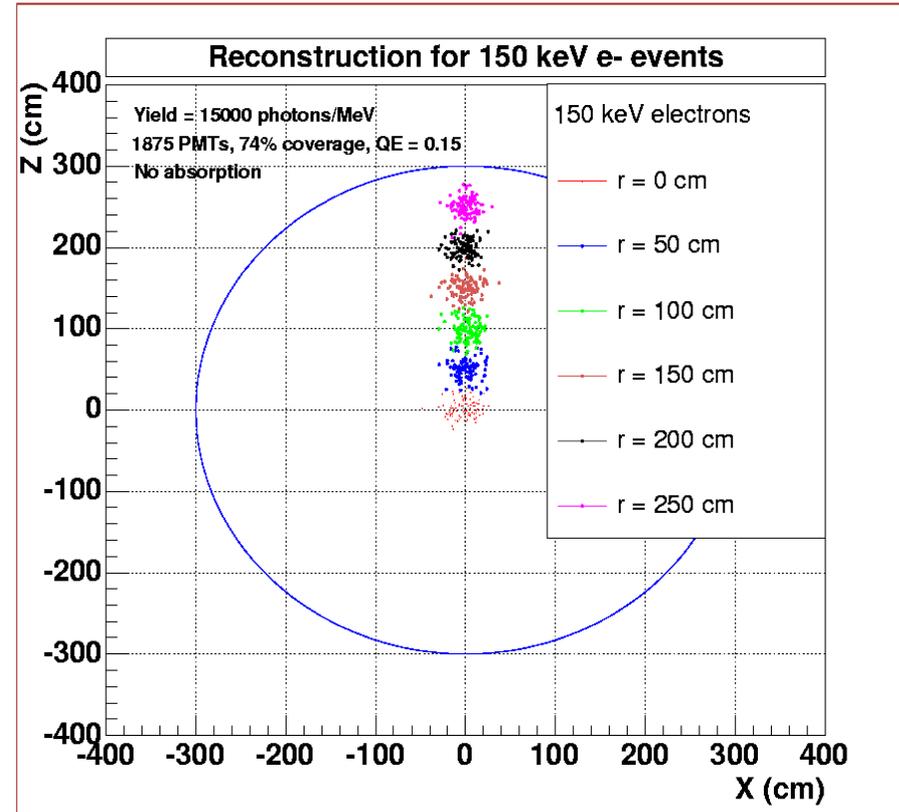
- Ultra-low internal backgrounds can be achieved in liquid Neon for keV-thresholds required for pp detection
- High scintillation yield $\rightarrow \sim 15000$ photons/MeV allows good reconstruction and energy resolution
- Liquid Neon transparent to its scintillation light
- Large volume detector allows separation from external source backgrounds using position reconstruction
- Scintillation time properties allow separation of ν 's and WIMPs (combination pp + WIMP experiment)

Scintillation events in CLEAN

- 15000 photons/MeV
- 60 cm Rayleigh scattering at 80 nm
- ~75% coverage, 15% PMT QE
- 80 nm shifted to blue for detection



250 keV electron at $z=250$ cm



Reconstruction for 150 keV electrons

PRELIMINARY

Backgrounds, backgrounds, backgrounds

Q: Can we get a large enough fiducial target with a low enough energy threshold to achieve sensitivity to WIMPs with parameters in interesting regions?

A: **It depends...** On

External radioactivity → reconstruction cuts

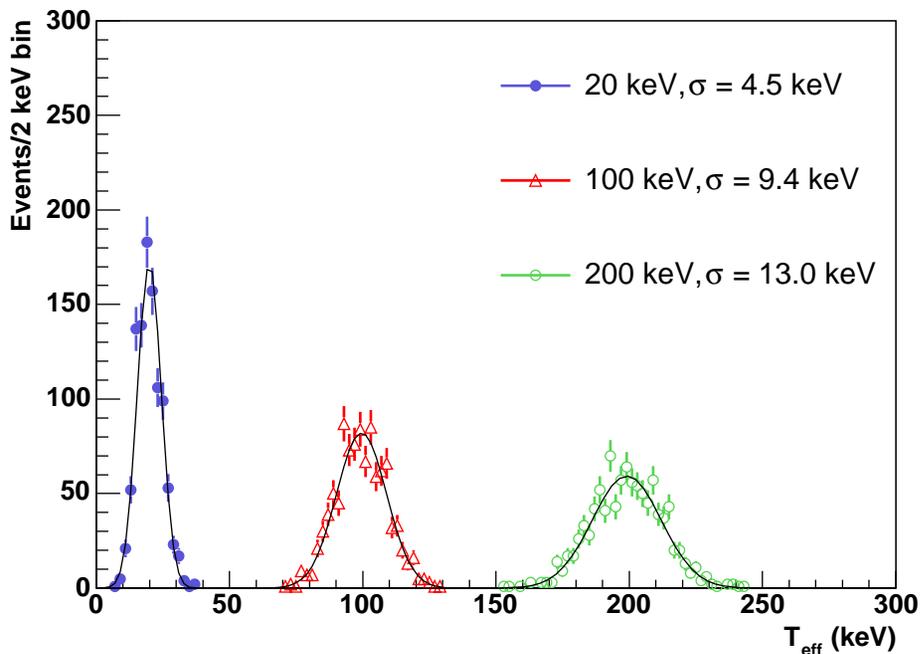
Internal radioactivity → clean

materials+analysis

Neutrino vs WIMP separation → timing

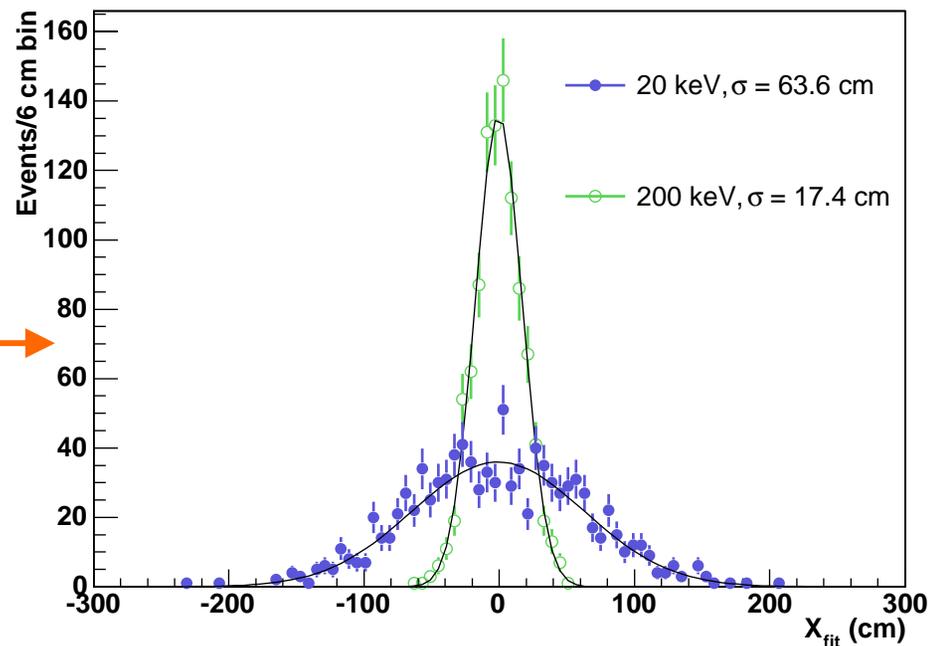
Total volume, light yield, detector optics, ...

Energy and position reconstruction in CLEAN



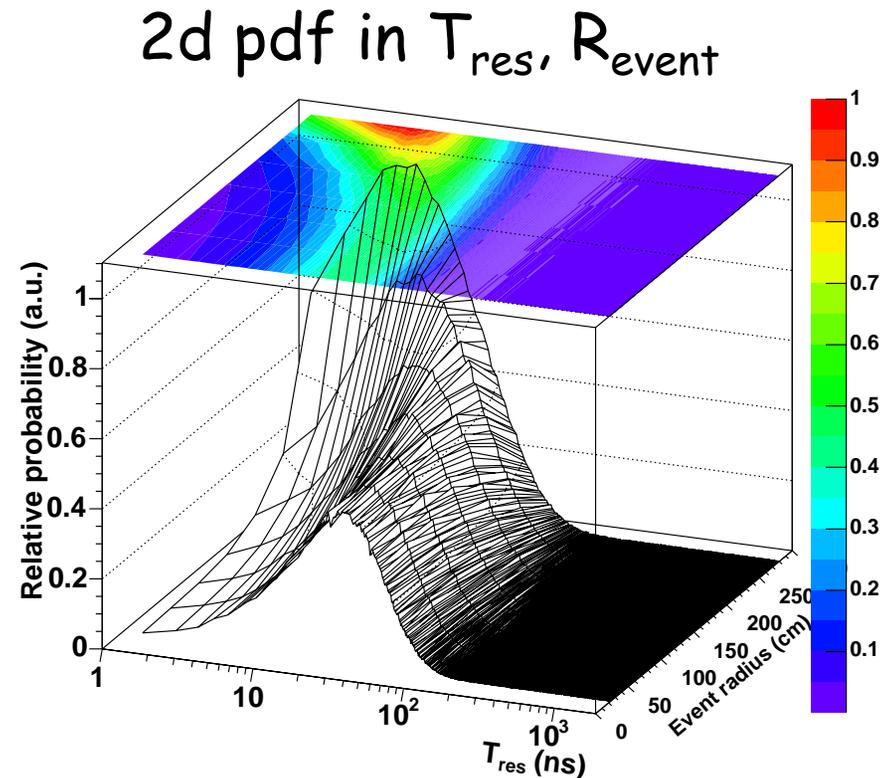
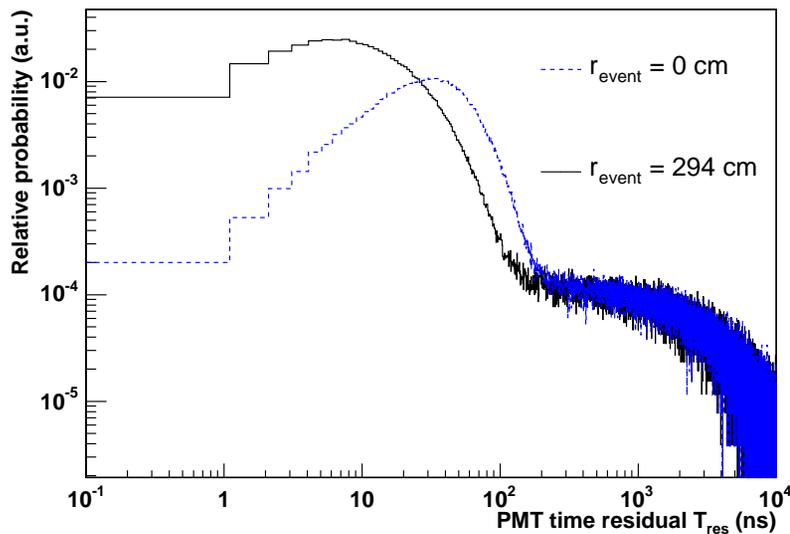
Energy reconstruction based on total number of photons detected in PMTs for 20, 100, and 200 keV events

Position reconstruction based on hit PMT positions for 20, 200 keV events



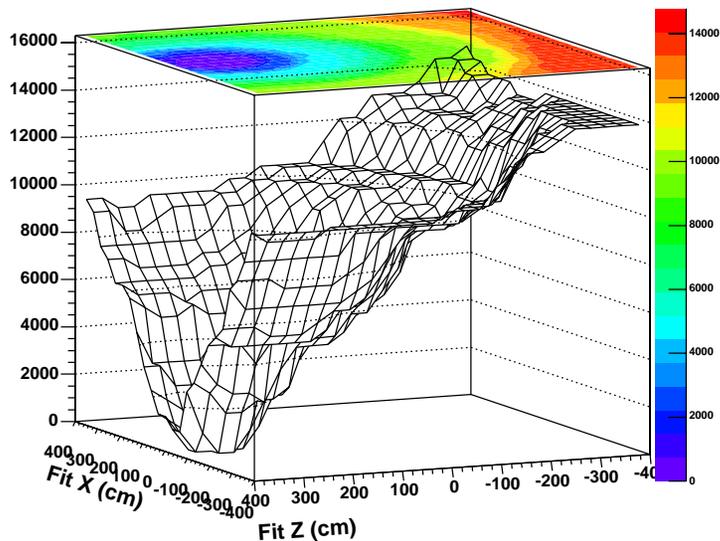
Time-of-flight (TOF) information for vertex reconstruction

$$T_{\text{res}} = T_{\text{pmt}} - T_{\text{fit}} - d_{\text{pmt}}/v_{\text{photon}}$$



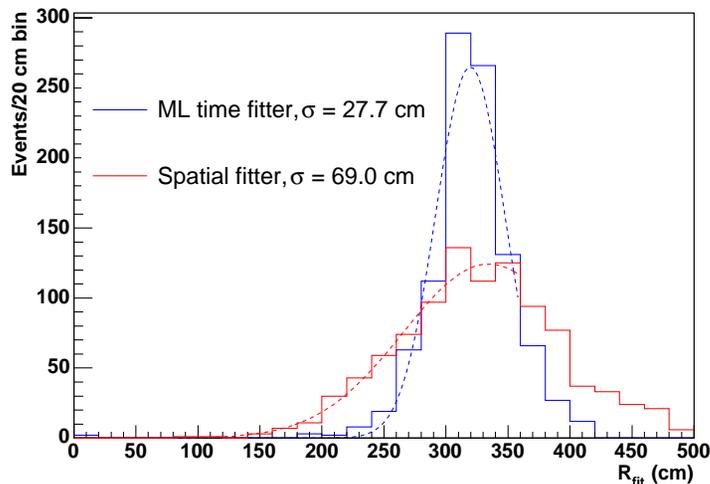
Scattering introduces position dependence to T_{res} , and broadens the distribution, but this info is still useful...

Likelihood surface using TOF information



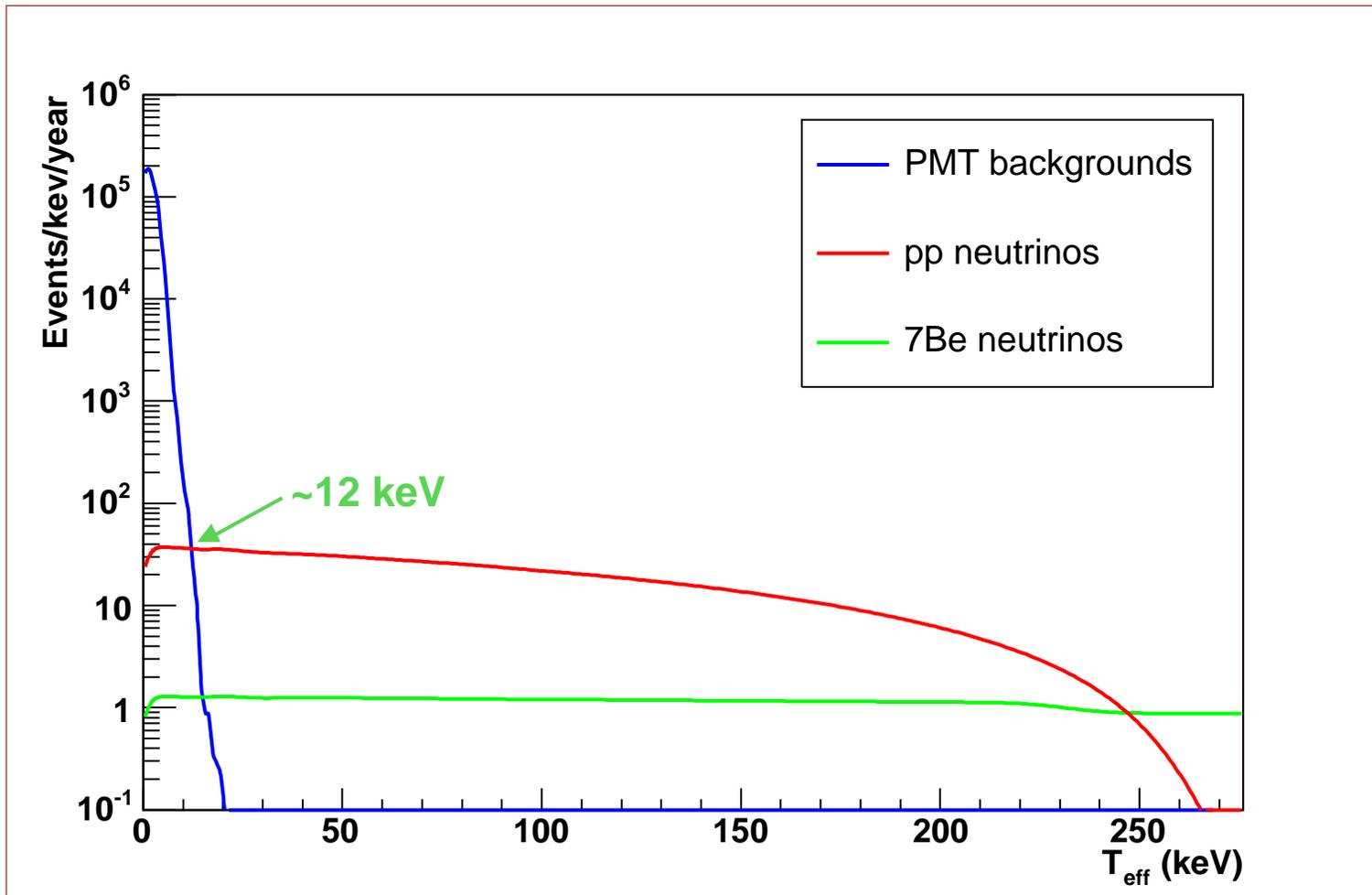
Likelihood surface (in detector x,y coordinates) for event at $x = 294$ cm, near PMT

Deep minimum near event location
In likelihood surface can be used to precisely locate event, improve Background rejection



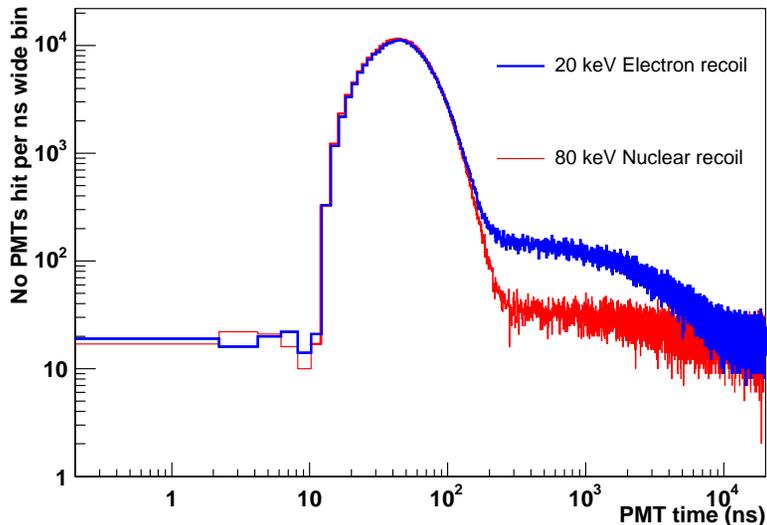
X2 improvement in position resolution with TOF information!

External backgrounds after fiducial cut



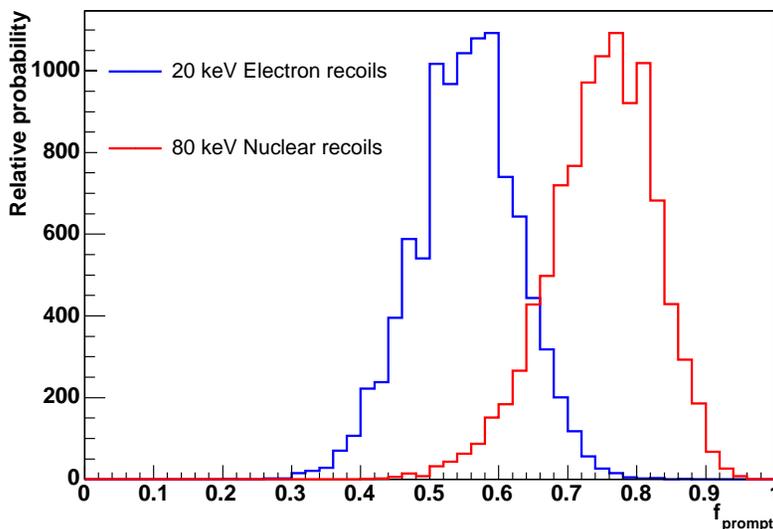
"sample" 300 cm detector with 125 cm fiducial cut

Distinguishing WIMPs from electrons



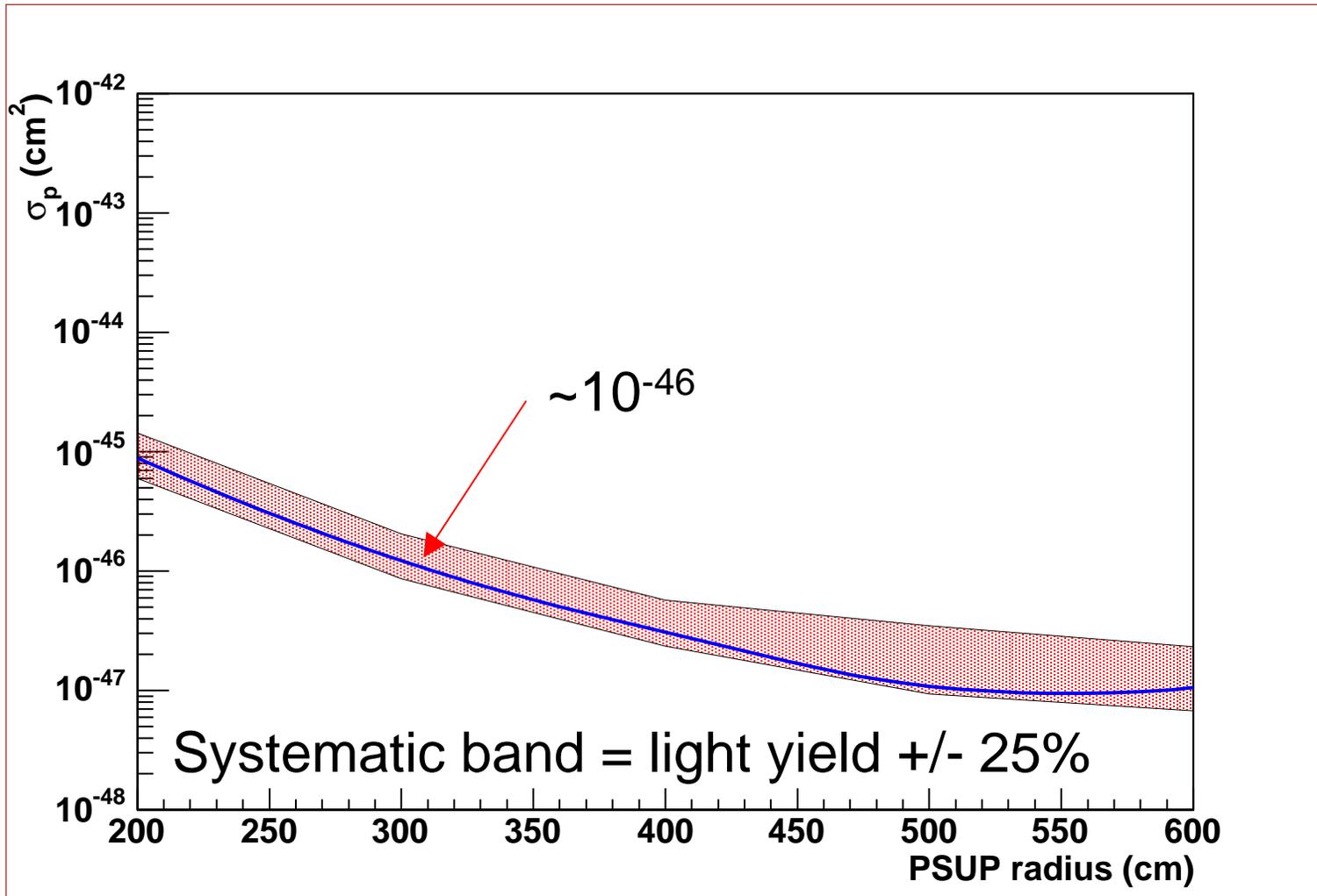
Time distribution of PMT hits
Are different for electron recoils
(neutrinos) and nuclear recoils
(WIMPs)

Ratio of prompt/late hits can
separate (statistically) electron
and nuclear recoils

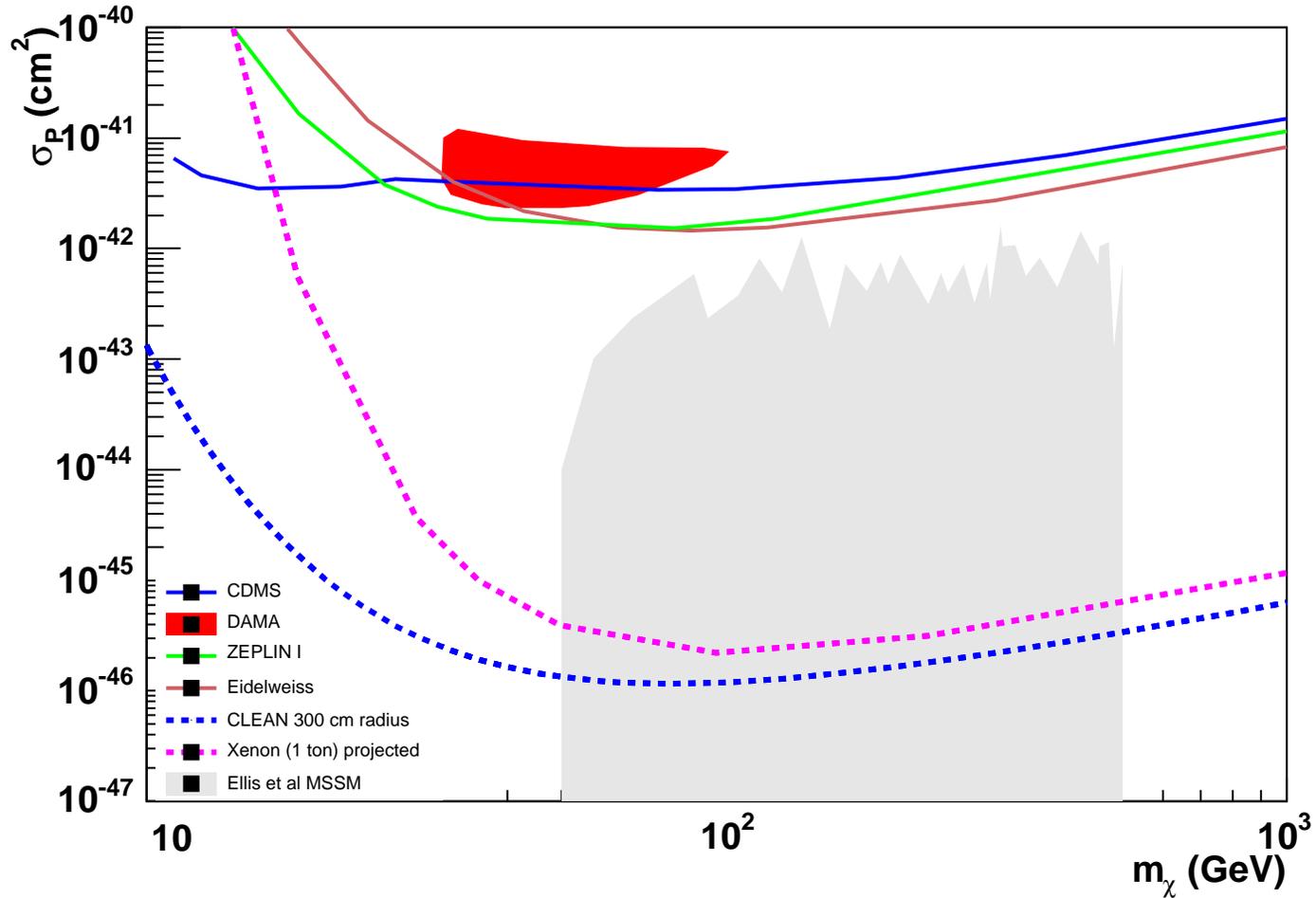


->From simulation, limit on WIMP
events is ~ 1 event/year in solar
neutrino background for 125 cm
volume of Neon.

Sensitivity to WIMPs with liquid neon



Dark matter sensitivity with Liquid Neon



Conclusions

Preliminary simulations with “nominal” scintillation properties show promising dark matter potential

Measurements of scintillation properties and backgrounds needed to further quantify dark matter sensitivity

Currently setting up to perform some of these at LANL and Yale

